

## 9.

Caudal Skeleton of Bermuda Shallow Water Fishes. IV.  
Order Cyprinodontes: Cyprinodontidae, Poeciliidae.<sup>1</sup>

GLORIA HOLLISTER

Department of Tropical Research.

(Text-figures 1-17).

## OUTLINE.

|   | Page |
|---|------|
| Introduction .....                              | 97   |
| Bermuda Cyprinodontes:                          |      |
| Cyprinodontidae: <i>Fundulus bermudae</i> ..... | 98   |
| Key .....                                       | 99   |
| Poeciliidae: <i>Mollienisia sphenops</i> .....  | 101  |
| <i>Gambusia holbrooki</i> .....                 | 106  |
| <i>Lebistes reticulatus</i> .....               | 109  |
| Summary .....                                   | 112  |

## INTRODUCTION.

This is the fourth of a series of papers dealing with the caudal skeleton of Bermuda fishes.<sup>2</sup> The shallow-water Iniomi of Bermuda is represented by two families, four genera and four species. Of these, *Fundulus bermudae*, a Cyprinodontidae, is a native, whereas all the Poeciliidae have been introduced. *Gambusia holbrooki*, a common species of the Eastern States from Delaware to Florida and now thriving in Bermuda marshes, was brought from fresh-water ponds near Washington, D. C., and planted in Pembroke Marsh and others in May, 1928. *Gambusia* thrive in our Bermuda fresh-water pools at Nonsuch as well as in the brackish marshes where they serve to control the breeding of mosquito larvae. Dr. Henry Wilkinson of the Medical and Health Department of Bermuda reports that, "for the most part they have done extremely well in brackish marshes. In some places, however, as Shelly Bay, they do not always last, but I think birds are the difficulty there and not salinity or other chemical substances. This fish is most adaptable. They stay near the surface, use their upturned mouth for mosquito larvae and give birth to a multitude of live fish. About half the *Gambusia* died coming here from Washington. The survivors were put directly into the various marshes and did well everywhere except in the marsh at Baileys Bay (which has since been filled). For this marsh a few of them had to be adapted by gradually stepping up the salinity in a bowl."

<sup>1</sup> Contribution No. 593, Department of Tropical Research, New York Zoological Society.

Contribution from the Bermuda Biological Station for Research, Inc.

<sup>2</sup> Caudal Skeleton of Bermuda Shallow Water Fishes. I. Order Isospondyli: Elopidae, Megalopidae, Albulidae, Clupeidae, Dussumieriidae, Engraulidae. *Zoologica*, New York Zoological Society, Vol. XXI, Dec. 31, 1936.

Caudal Skeleton of Bermuda Shallow Water Fishes. II. Order Percomorphi, Suborder Percosoces: Atherinidae, Mugilidae, Sphyraenidae. *Zoologica*, New York Zoological Society, Vol. XXII, Oct. 7, 1937.

Caudal Skeleton of Bermuda Shallow Water Fishes. III. Order Iniomi: Synodontidae. *Zoologica*, New York Zoological Society, Vol. XXII, Dec. 31, 1937.

During a series of experiments to determine "Salt and Fresh-water Viability of Fish"<sup>3</sup> I found that *Gambusia* need a few days (one day was successful in several cases) in a 50-50% solution, before thriving in pure sea-water. Placed directly in sea-water they survive about three hours. Later it was found that of the minnows the guppy is the least adaptable to salt-water, needing gradual changes over a period of about a week. *Fundulus* adapts itself more readily than the others to either fresh or salt water, without any intermediate steps in half-and-half solutions. Recently *Lebistes* and *Mollienisia* have been taken to Bermuda and placed in garden lily pools, where they thrive all the year around.

For Caudal Fin Terminology, Caudal Bibliography, and method of preparing specimens for this study refer to Caudal I. The length of specimens in this paper is standard length unless otherwise stated.

The symbols used in the figures are 1C, 1st caudal vertebra; 2C, 2nd caudal vertebra; 3C, 3rd caudal vertebra; EP, epural; 1, 2, 3, hypurals; T, last trunk vertebra.

I am indebted to Dr. and Mrs. Carl Hubbs for a complete series of *Mollienisia sphenops* which range in age from less than 24 hours to 9 weeks, as well as adults with an exact record of their ages when they were placed in spirits; to Curator Lee S. Crandall, Keeper Scott and Head Gardener George Skene for adult and young *Lebistes*; to Dr. Henry Wilkinson for information concerning the introduction of *Gambusia* to Bermuda; to Thatcher Adams for collecting *Gambusia* from the Bermuda marshes; to Dr. William Beebe, Director of this Department, and Mr. John Tee-Van, General Associate, for their cooperation.

The drawings are by Miss Harriet Bennett and Miss Janet Wilson.

### 1. *Fundulus bermudae* Günther.

(Text-fig. 5).

#### Diagnostic Characters:

Caudal fin count not less than  $\frac{20}{19}$ , usually  $\frac{8 + 12}{7 + 12}$ .

Caudal raylets extend anteriorly to approximately the fifth posterior neural and haemal spines.

No modification of ventral structure of anterior caudal vertebrae adjacent to the anal fin in male. Anal fin in male and female similar in this oviparous fish.

5 posterior neurals and haemals elongated into the caudal contour.

Vertebral count: 12 to 14 trunk, plus 19 to 21 caudal. Total 31, 33, 35.

1 epural.

1 large fan-shaped hypural and 1 slender ventral hypural.

#### Material Studied.

| Length.       | KOH Cat. No. | Cat. No. | Text-fig. No. |
|---------------|--------------|----------|---------------|
| 81 mm.        | 1105         | 25,113   | 5             |
| 76 mm.        | 1106         | 25,113   |               |
| 72 mm.        | 2226         | 25,112   |               |
| (4) 66-61 mm. | 1109         | 25,113   |               |
| 59-56 mm.     | 2226         | 25,112   |               |
| (4) 54-46 mm. | 1108         | 25,113   |               |
| 44 mm.        | 2226         | 25,112   |               |
| (8) 42-26 mm. | 1107         | 25,113   |               |

<sup>3</sup>Hollister, 1934. Salt and Fresh Water Viability of Fish. New York Zoological Society Bulletin, Vol. XXXVII, No. 6, Nov.-Dec., 1934.

Breder, 1934. Ecology of an Oceanic Fresh-water Lake. Zoologica, New York Zoological Society, Vol. XVIII, No. 3, August, 1934. See Bibliography.

KEY TO CAUDAL FIN OF BERMUDA SHALLOW WATER CYPRINODONTID FISHES.

(Text-figs. 1-4).

C  
Y  
P  
R  
I  
N  
O  
D  
O  
N  
T  
I  
D  
E  
S

**Group I CYPRINODONTIDAE**

*Fundulus bermudae*

Caudal fin count not less than  $\frac{20}{19}$ , usually  $\frac{8 + 12}{7 + 12}$ .

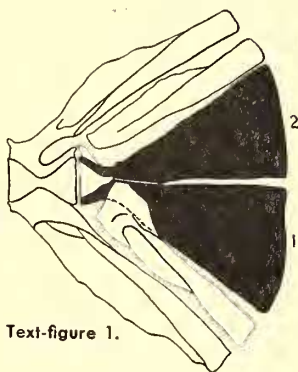
Caudal raylets extend anteriorly to approximately the fifth posterior neural and haemal spines.

No modification of ventral structure of anterior caudal vertebrae adjacent to anal fin in male.

**Sub-Group A *Mollienisia sphenops***

Caudal fin count usually  $\frac{15-16}{16}$  or  $\frac{16}{15}$ .

Median hypurals completely divided in mid-line forming a dorsal and ventral half.



Text-figure 1.

**Group II POECILIDAE**

Caudal fin count less than  $\frac{20}{19}$ .

Caudal raylets extend anteriorly to approximately the third posterior neural and haemal spines.

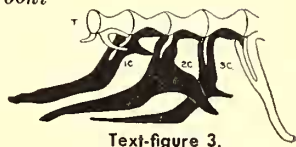
Modification of ventral structure of anterior caudal vertebrae adjacent to anal fin in male.

**Division I *Gambusia holbrooki***

Modification of anterior three caudal vertebrae in male.

Caudal vertebrae 18 to 20.

Total vertebrae 31 to 33; 13 + 18 to 20.

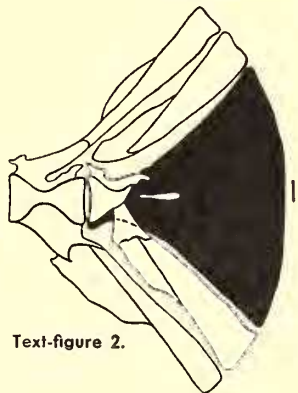


Text-figure 3.

**Sub-Group B**

Caudal fin count less than A, usually  $\frac{12}{13}$  or  $\frac{13}{13}$ .

Median hypural not completely divided in mid-line.



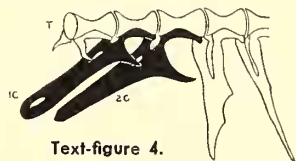
Text-figure 2.

**Division II *Lebistes reticulatus***

Modification of anterior two caudal vertebrae in male.

Caudal vertebrae 14 to 17.

Total vertebrae 26 to 29; 12 + 14 to 17.

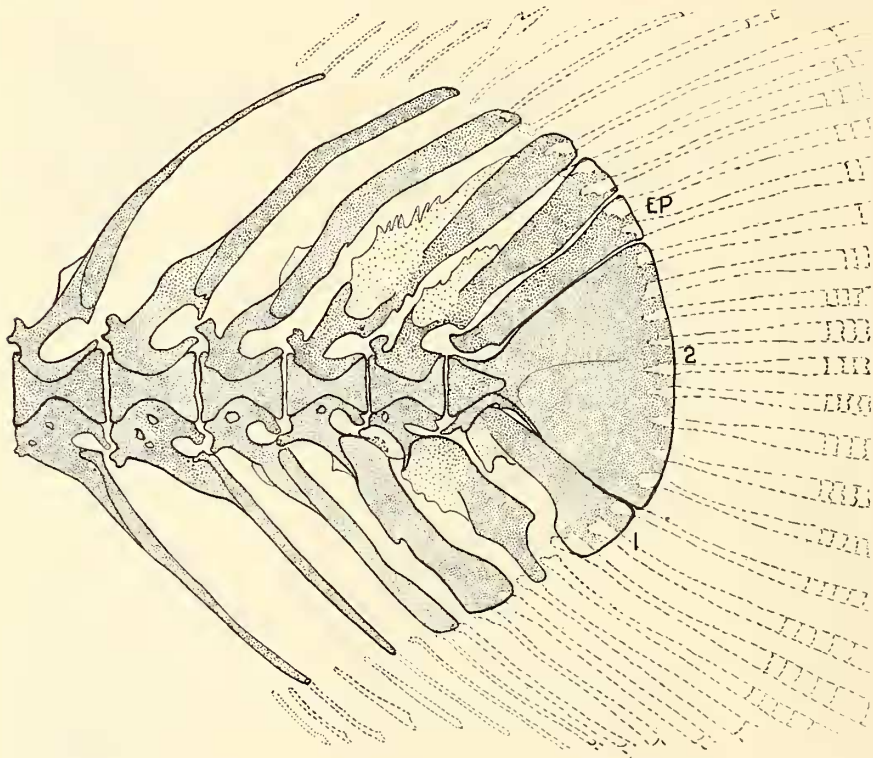


Text-figure 4.

## Caudal Osteology.

*Urostyle*: Separate segments of the urostyle cannot be found in any specimens examined which range in size from 26 mm. to 81 mm. The urostyle is conical in shape and the blunt posterior end can be seen in some specimens at the base of the fan-shaped hypural. The urostyle appears completely consolidated with the median hypural.

*Uroneurals*: In several of the smaller specimens a slender paired bone extends along the dorsal surface of the fan-shaped hypural. This may be a uroneural. In larger specimens this cannot be seen but in all there is a marked irregularity in the shape and size of the reduced neural on the anterior part of the urostyle.



Text-figure 5.

*Fundulus bermudae*. Length 81 mm. and largest in collection. Shows solid dorsal hypural, raylets reaching as far forward as fifth from last neural and haemal, and wing growths on the posterior neurals and haemals which are irregular in the different specimens.  $\times 15.4$ .

*Hypurals*: There are two hypurals in all specimens studied. The dorsal fan-shaped hypural is three and a half times wider on the distal margin than the second hypural. The larger bone is median and terminal in position and supports about ten caudal rays. There are no lines to indicate that this large hypural is a fusion of several bones, but very young specimens are not available. The smaller hypural is entirely ventral in position with its base abutting the ventral surface of the cone-shaped urostyle. In all specimens the size and shape of the smaller hypural is irregular. In larger fish there is a thin wing on the anterior surface. There is also marked variation



in position of the base of the hypural. In some specimens this is close to the urostyle but in others there is considerable space between. In one large specimen the distal half of the smaller hypural is fused with the adjacent and ventral side of the larger hypural.

*Epural*: There is one epural in all of our specimens. This bone is similar in shape and position to the ventral hypural and the two flank respectively, the anterior ventral and the anterior dorsal surfaces of the median fan-shaped hypural. The basal end of the epural varies in exact position in the different specimens, which is also seen in the base of the hypural which is opposite.

*Caudal Fin Ray Count*:

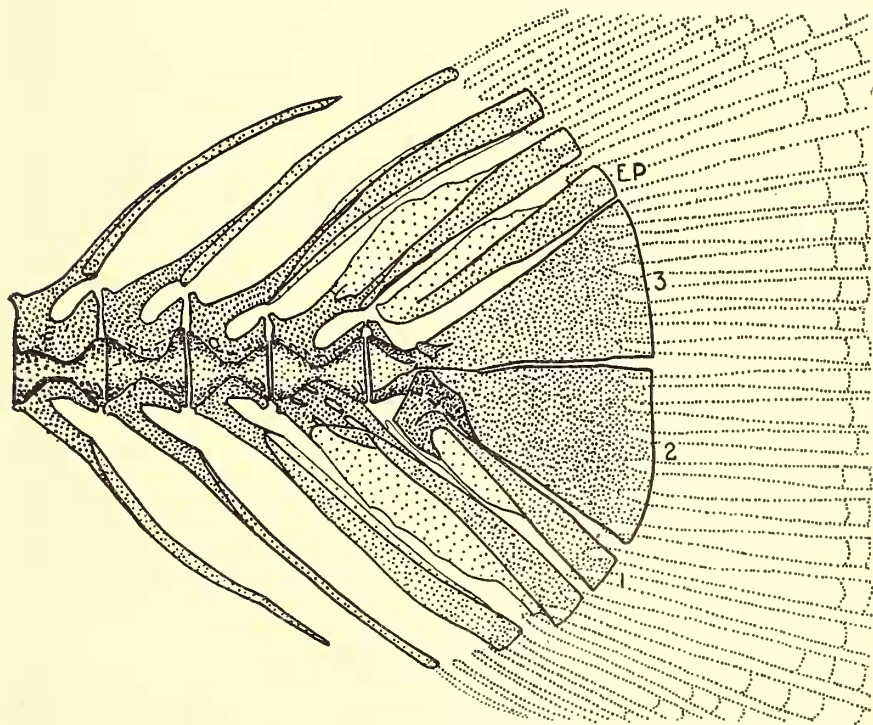
$$\frac{7 \text{ or } 8 + 12}{7 \text{ or } 8 + 12} = \frac{19 \text{ or } 20}{19 \text{ or } 20}$$

2. *Mollienisia sphenops* (Cuvier & Valenciennes).

(Text-figs. 6-11).

*Diagnostic Characters*:

Caudal fin count usually  $\frac{16}{16}$  or 1 more or less.



Text-figure 6.

*Mollienisia sphenops*. Adult female, length 38 mm. This is typical of the adult male and female and shows the two large median hypurals characteristic of this species.  $\times 27.5$ .

*Diagnostic Characters* (continued):

Caudal raylets extend anteriorly to approximately the third posterior neural and haemal spines.

Modification of two anterior caudal vertebrae in male. Anal fin in male specialized in this viviparous species.

3 posterior neurals and haemals elongated into the caudal contour.

Vertebral count: 12 trunk, plus 16 to 18 caudal. Total 28 to 30.

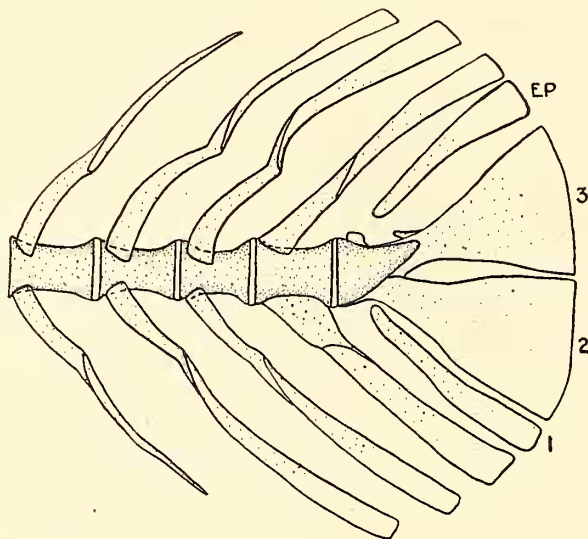
1 epural.

2 large hypurals and 1 slender hypural.

*Material Studied.*

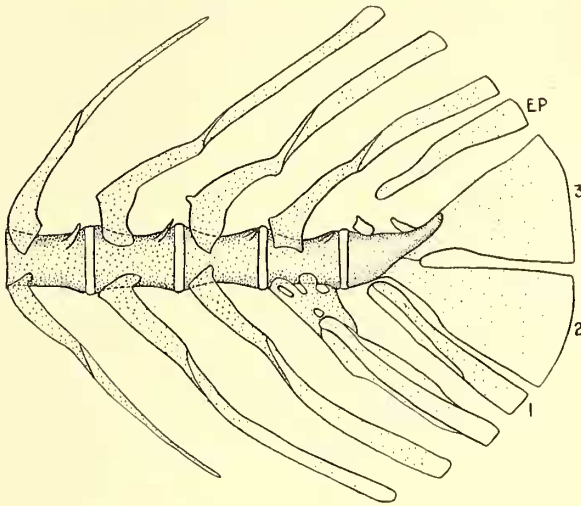
Drawings and descriptions are made from *Mollienisia sphenops* from Acapulco, Mexico. The key is based on this material also.

|                                       | <i>Length.</i>      | <i>KOH Cat. No.</i> | <i>Text-fig. No.</i> |
|---------------------------------------|---------------------|---------------------|----------------------|
| (2) 1 day or less old                 | 7 mm.               | 2211                | 7                    |
| (2) 1 week old                        | 8 & 9 mm.           | 2212                | 8                    |
| (2) 2 weeks old                       | 10 mm.              | 2213                | 9                    |
| (1) 3 weeks old                       | 12 mm.              | 2214                | 10                   |
| (2) About 3 weeks old                 | 12 mm.              | 2215                |                      |
| (2) About 4 weeks old                 | 14 mm.              | 2216                |                      |
| (2) About 5 weeks old                 | 15 mm.              | 2217                |                      |
| (2) About 6 weeks old                 | 16 mm.              | 2218                |                      |
| (2) 7 weeks old                       | 17 mm.              | 2219                |                      |
| (2) 9 weeks old                       | 18 mm.              | 2220                |                      |
| (2) About 9 weeks old                 | 18 mm.              | 2221                |                      |
| (5) Adults (S AC stock),<br>3 females | 31 mm. & (2) 38 mm. | 2248                | 6                    |
| 2 males                               | 26 mm. & 29 mm.     | 2248                | 11                   |



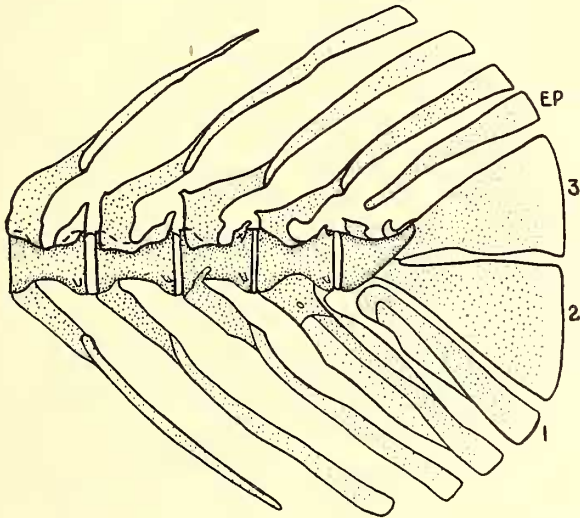
Text-figure 7.

*Mollienisia sphenops*. 1 day old, length 7 mm. Shows delicate ossification of the caudal area which diminishes gradually toward the distal ends of the neurals, haemals and hypurals. The urostyle is upturned and longer than the older specimens. The column is unsegmented. Wing growths have not developed on the posterior neurals and haemals. As in the adults, the two large hypurals are differentiated.  $\times 73.5$ .



Text-figure 8.

*Mollienisia sphenops*. 1 week old, length 9 mm. Shows general increase of ossification and the urostyle elongated and upturned and the column still unsegmented. Appearance of dorsal posterior zygapophyses and wing growths on the last ventral haemal spine and the first hypural.  $\times 57.2$ .



Text-figure 9.

*Mollienisia sphenops*. 2 weeks old, length 10 mm. The centra show the spool-shape of the adult. The column is unsegmented and there is a continued increase in ossification.  $\times 50$ .

***Mollienisia sphenops* ssp.**

From Lake Petén, Guatemala.

|                            |      |
|----------------------------|------|
| (2) Less than 24 hours old | 2232 |
| (2) 1 week old             | 2233 |
| (2) 2 weeks old            | 2234 |
| (2) 3 weeks old            | 2235 |
| (1) 4 weeks old            | 2236 |
| (2) About 4½ weeks old     | 2237 |
| (1) 4 weeks old            | 2238 |
| (2) 5 weeks old            | 2239 |
| (2) 6 weeks old            | 2240 |
| (2) 7 weeks old            | 2241 |
| (1) About 7 weeks old      | 2242 |
| (2) About 8 weeks old      | 2243 |
| (2) 9 weeks old            | 2244 |
| (6) Adults                 | 2249 |

From Subine River, Guatemala.

|                            |      |
|----------------------------|------|
| (2) Less than 24 hours old | 2228 |
| (2) 1 week old             | 2229 |
| (2) 2 weeks old            | 2230 |
| (2) 3 weeks old            | 2231 |

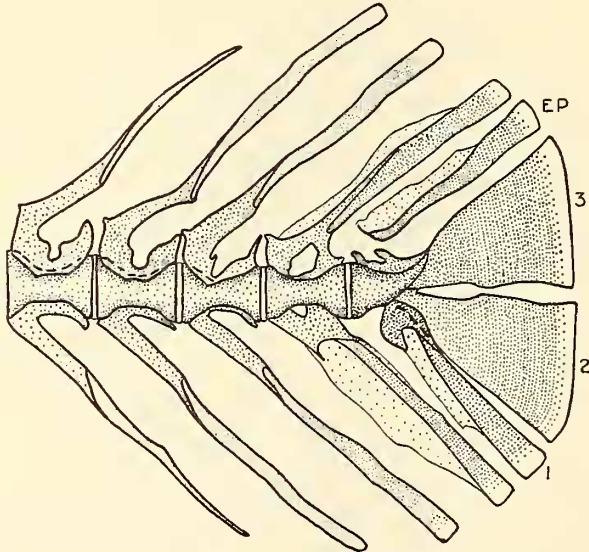
"Sail-fin" variety.

From New York City—Tank-bred.

|                |      |
|----------------|------|
| (2) Adults     | 2227 |
| (1) Adult male | 2206 |

*Caudal Osteology.*

*Urostyle*: In adult specimens the terminal tip of the urostyle is very much reduced and in some hidden by the basal structure of the hypurals.



Text-figure 10.

*Mollienisia sphenops*, 3 weeks, length 12 mm. Degree of ossification and general shape of bones the same as stages between this age and the adult. Column still unsegmented but in a specimen slightly older the centra are separate.  $\times 39.8$ .



No separate segments can be found in any growth stages. In the young fish from one day to nine weeks of age the terminal end of the urostyle is up-turned and prolonged. Reduced paired neurals are present in all stages and there is variation in size and shape.

*Uroneurals*: There is no evidence of uroneurals.

*Hypurals*: There are three hypurals in young and adult specimens of all stages—two large median bones and one slender ventral hypural. The two large bones are approximately the same size and together form the posterior caudal contour and support approximately twelve rays. With high magnification a line can be found continuing anteriorly from the open median slit in all specimens. In one small specimen there is space between the two bases but in others the bases appear as one. There is considerable ossification in the caudal region of the young of this viviparous species. The third hypural is ventral in position and the basal part of the two lateral sides of the arch overlap the base of the adjacent hypural. The thin wing of bone on the anterior side varies in length and shape in the adult and is not present in the very young specimens.

*Epural*: There is a single epural in all specimens, which resembles the small hypural without the arch. In young specimens there is no wing-growth present.

*Caudal Fin Ray Count*:

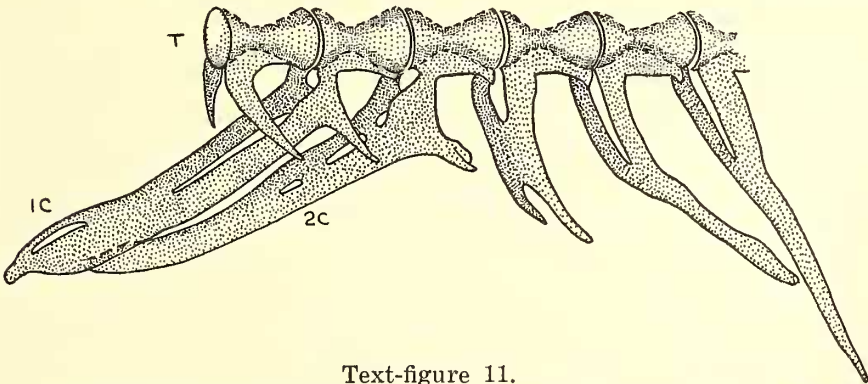
$$\frac{3 + 12}{3 + 13}, \frac{3 + 13}{3 + 13}, \frac{3 + 12}{2 + 13} = \frac{15}{16}, \frac{16}{16}, \frac{16}{15}$$

In the subspecies from Lake Petén, Guatemala, the count is;

$$\frac{4 + 12}{5 + 12}, \frac{5 + 12}{5 + 12} = \frac{16}{17}, \frac{17}{17}$$

In addition to the increase in the anterior raylets, in most specimens the fourth posterior neurals and haemals are prolonged into the caudal contour. In none of the *sphenops* is this found.

*Additional Characters Worthy of Note*: A paper on the caudal skeleton of cyprinodonts would hardly be complete without mention of the specialized caudal haemals found in the male poeciliids. As in *Gambusia* and *Lebistes*,



Text-figure 11.

*Mollienisia sphenops*. Anterior caudal haemals of adult male, length 29 mm. The last trunk, or abdominal process, is followed by the first and second caudal which are specialized in the male. The first caudal has an opening in the tip for the insertion of the dorsal ends of the posterior interhaemals. The two openings in the second caudal are not constant in all of the specimens. The ribs and neurals have been omitted for clarity.  $\times 27.5$ .

the anterior caudal haemals are specialized in the male. Also the total number of caudal vertebrae is identical in the males and females. But in the adult males the anterior two caudal haemals are specialized. Each is a long heavy bone slanting in an anterior direction as far as the dorsal ends of the interhaemals. As in *Lebistes*, paired pointed projections extend posteriorly from the lateral sides of the closed haemal arch and can overlap the next posterior haemal process. No caudal haemal specialization can be found in the young up to nine weeks of age and material between this age and adults is not at hand.

### 3. *Gambusia holbrooki* (Girard).

(Text-figs. 12-14).

#### Diagnostic Characters:

Caudal fin count usually  $\frac{12, 12, 13}{13 \ 14 \ 13}$ .

Caudal raylets extend anteriorly to approximately the third posterior neural and haemal spines.

Modification of anterior three caudal vertebrae in male. Anal fin in male specialized in this viviparous species.

4 posterior neurals and haemals elongated into the caudal contour. Vertebral count: 13 trunk, plus 18 to 20 caudal. Total 31 to 33. 1 epural.

1 large fan-shaped hypural and 1 slender hypural. Median hypural not completely divided in mid-line.

#### Material Studied.

| Length.                    | KOH Cat. No. | Text-fig. No. |
|----------------------------|--------------|---------------|
| (25) Males 16-25 mm.       | 2225         |               |
| (27) Females 15-31 mm.     | 2225         | 12            |
| (12) Embryos 5 mm.         | 2225A        | 13            |
| (6) Dissected male haemals | 2225         | 14            |

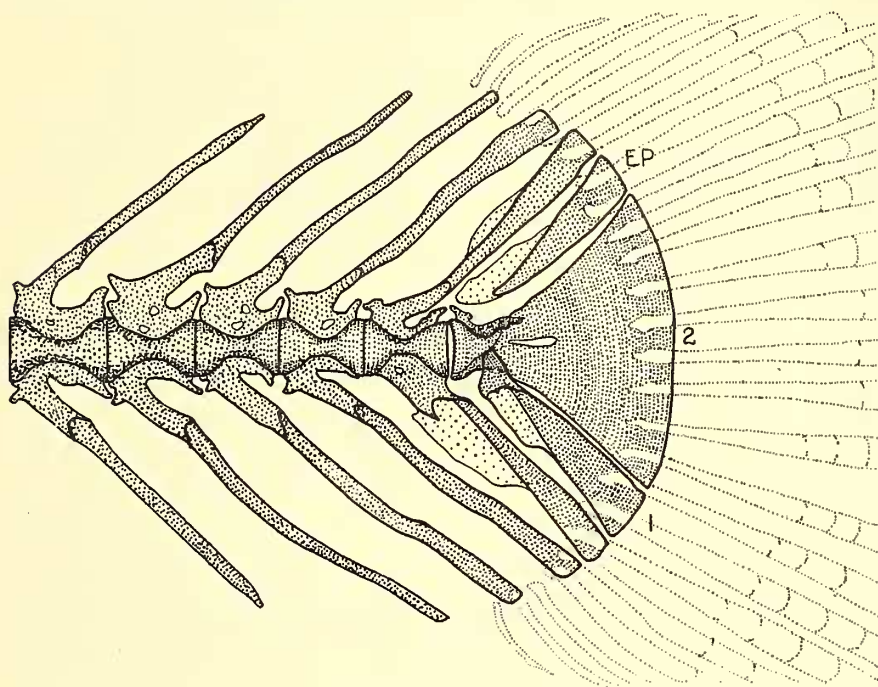
#### Caudal Osteology.

*Urostyle*: The urostyle is almost a perfect half centrum and conical in shape. The posterior tip is blunt and upturned and can be seen in most specimens at the base of the fan-shaped hypural. No separate segments of the urostyle can be found even in the 5 mm. embryos. In these young specimens the upturned tip of the urostyle is less reduced and proportionately larger than in the full-grown fish. In both the embryos and adults the urostyle appears consolidated with the median hypural. In embryos and adults either one or two reduced neurals are present on the urostyle.

*Uroneurals*: There is no trace of uroneurals in any of the specimens.

*Hypurals*: There are two hypurals present in all specimens both embryo and adult. The large median hypural is fan-shaped and approximately five and a half times broader on the distal margin than the ventral hypural. The larger hypural supports about ten caudal rays. In all but a few of the specimens there is a median slit near the base of the large hypural. The distance that this opening extends posteriorly is variable and cannot be correlated with sex or age. In one of the embryos and two adults a delicate line is seen with the high power lens which extends through the anterior base of the hypurals to the slit-opening. The study of younger embryos might determine whether or not this large hypural is at one time definitely divided.

But in none of the specimens is there any indication of a division of the distal part of the hypural. Considerable ossification exists in the caudal region of the young of these ovoviviparous embryos. The smaller hypural is entirely ventral in position. The bases of the two lateral sides, comparable to the haemal arches in the anterior processes, overlap the base of the larger hypural. In all of our specimens there is variation in the size and details of the shape of these haemal bases.



Text-figure 12.

*Gambusia holbrooki*. Adult female, length 28 mm. This caudal represents a typical adult male and female. The single fan-shaped hypural is characteristic of this species.  $\times 20.84$ .

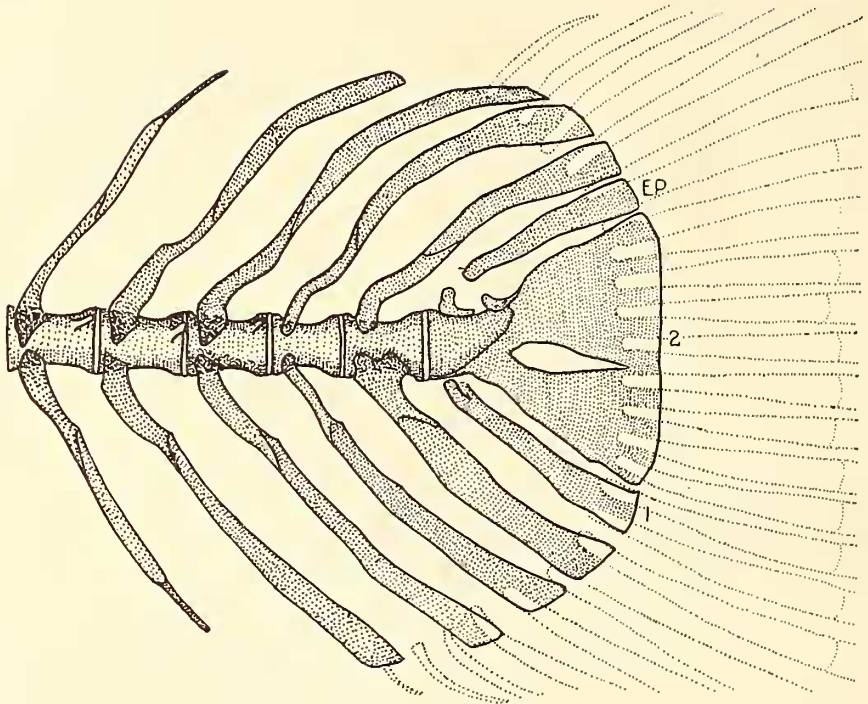
*Epural*: There is one epural in all specimens. This bone is similar in shape and position to the corresponding element, the ventral hypural, and the two flank respectively the anterior ventral and anterior dorsal surfaces of the median fan-shaped hypural. Similar to the hypural, the basal end of the epural varies in exact position in the different specimens.

*Caudal Fin Ray Count*:

$$\frac{2 \text{ or } 3 + 10}{3 + 10 \text{ or } 11} = \frac{12 \text{ or } 13}{13 \text{ or } 14}$$

*Additional Characters Worthy of Note*: The total number of caudal vertebrae is identical in the males and females of this series of *Gambusia holbrooki*. But in the males the three anterior caudal haemals are highly specialized. Each one is relatively large and dagger-shaped with the tips of the spines directed anteriorly as far as the dorsal ends of the interhaemal spines. Extending posteriorly from the region of the closed haemal arches are paired projections which are capable of overlapping the next posterior





Text-figure 13.

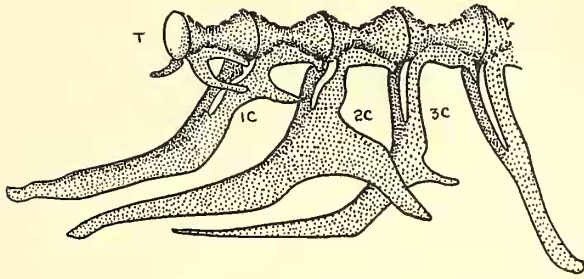
*Gambusia holbrooki*. Embryo, length 5 mm. There is considerable ossification in the caudal area but not in the head region. The column is unsegmented and the centra not spool-shaped as in the adult. The fan-shaped hypural shows no indication of separate elements.  $\times 86.84$ .

haemal process. For description of the mechanical functioning of these specialized male haemals see Collier's<sup>4</sup> splendid article on *Gambusia affinis affinis* (Baird & Girard). In comparing the detailed drawings of both the total skeleton and the specialized haemals of this species with the specialized haemals in our *Gambusia holbrooki*,<sup>5</sup> it is conspicuous that the anterior, or first, caudal of *Gambusia affinis affinis* is more slender and simple than that of *holbrooki*. It is to be assumed that Collier's illustrations are typical, and so this difference may be found to be a definite caudal character in the two species. No male caudal specialization can be determined in the twelve embryos. In the smallest adult males, (16 mm.), the anterior caudal haemals are differentiated but small, and the general appearance of the anal fin is like that of the young females. Although we lack stages between the 5 mm. embryos and the 16 mm. specimens, it would seem that the development of the specialized caudal haemals probably commences at approximately this latter age, and earlier than the development of the prolonged stout third anal ray characteristic of the adult male. In all specimens but two, up to 20 mm. long, there is no marked development of this ray which is, on very

<sup>4</sup> Collier, Albert, 1936. The Mechanism of Internal Fertilization in *Gambusia*. Copeia, No. 1, May 10, 1936.

<sup>5</sup> Langer, W. Fr., 1913. Beiträge zur Morphologie der viviparen Cyprinodontiden. Morphologisches Jahrbuch, 1913, vol. 47. pp. 193-307. 150 figs., 244 bibliographical references. Illustration of the specialized haemals in the male *Gambusia holbrooki*.





Text-figure 14.

*Gambusia holbrooki*. Anterior caudal haemals of adult male, length 24 mm. Shows the last trunk or abdominal process, and first three caudal which are specialized in the male. The ribs and neurals have been omitted for clarity. Unlike *Mollienisia* and *Lebistes* there are no openings in the haemals excepting those for the haemal vessel.  $\times 18$ .

close examination, found to be only a little stouter than the ray of the female of similar size. But in two specimens of 20 mm. the third ray is noticeably longer and the fourth and fifth are also prolonged. In the other males slightly larger the anal fin is completely developed.

#### 4. *Lebistes reticulatus* (Peters).

(Text-figs. 15-17).

##### Diagnostic Characters:

Caudal fin count usually  $\frac{12}{13}$ , or  $\frac{13}{13}$ .

Caudal raylets extend anteriorly to approximately the third neural and haemal spines and sometimes slightly beyond.

Modification of anterior two caudal vertebrae in the male. Anal fin specialized in this viviparous species.

4 posterior neurals and haemals elongated into the caudal contour. Vertebral count: 12 trunk plus 14 to 17 caudal. Total 26 to 29.

1 epural.

1 large fan-shaped hypural and 1 slender hypural.

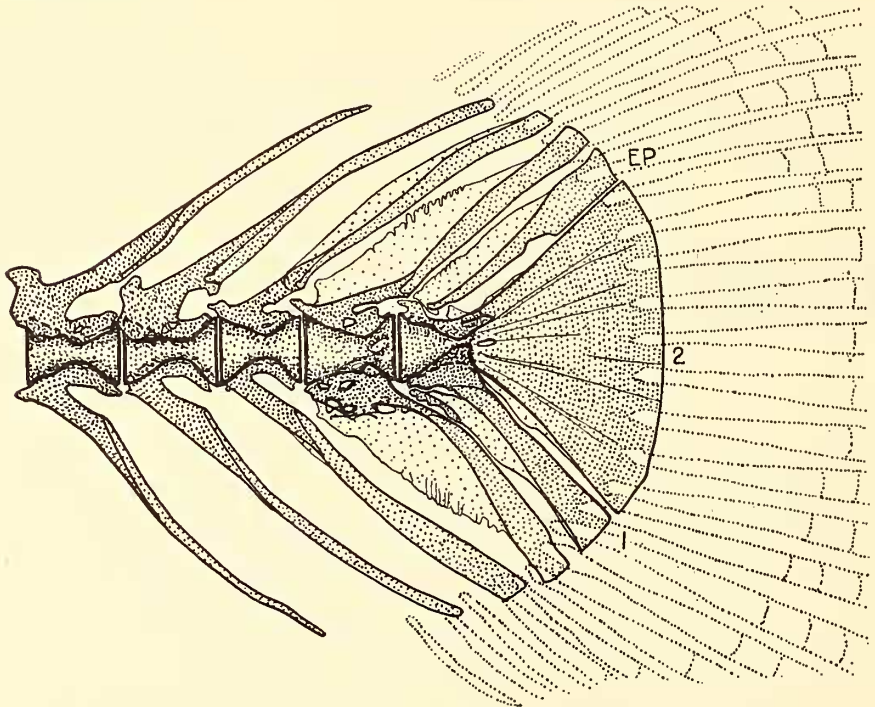
Median hypural not completely divided in mid-line.

##### Material Studied.

|   | Length.        | KOH Cat. No. | Text-fig. No. |
|---|----------------|--------------|---------------|
| (3) Males   | 15, 18, 20 mm. | 2252         |               |
| (3) Females   | 26, 28, 31 mm. | 2252         | 15            |
| (4) Males   | 15-18 mm.      | 2253         |               |
| (3) Females   | 25-27 mm.      | 2253         |               |
| (2) Males   | 13 & 18 mm.    | 2035         |               |
| (1) Female  | 29 mm.         | 2095         |               |
| (6) Young, 2½ months old.<br>2nd generation living in<br>sea water. | 8-12 mm.       | 2100         |               |
| (4) Young, 1 and 2 days   | 6, 8, 10 mm.   | 2311         |               |
| (2) Embryos   | 6 mm.          | 2309         | 16            |
| (4) Dissected male haemals  |                | 2252         | 17            |

## Caudal Osteology.

*Urostyle*: The slender upturned end of the urostyle can be seen in most of the specimens in the base of the large hypural. No separate segments can be found either in the 6 mm. embryo or the 6, 8 and 10 mm. young. In these small specimens the upturned end of the urostyle is proportionally larger and longer than in the adult fish. The urostyle and the base of the large hypural appear consolidated in specimens of all sizes. Reduced paired neurals are present on the urostyle in all specimens and there is variation in their size and shape.



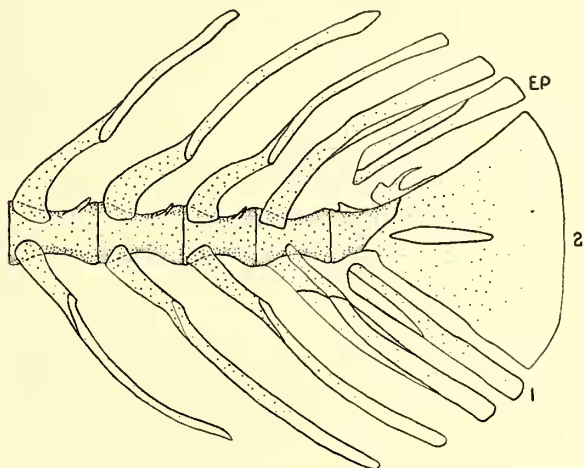
Text-figure 15.

*Lebistes reticulatus*. Adult female, length 28 mm. This caudal represents a typical adult male and female with the exception of the irregular lines on the second hypural. The growth lines in the large hypurals are not present in the young or the males.  $\times 16.9$ .

*Uroneurals*: There is no trace of uroneurals in our specimens.

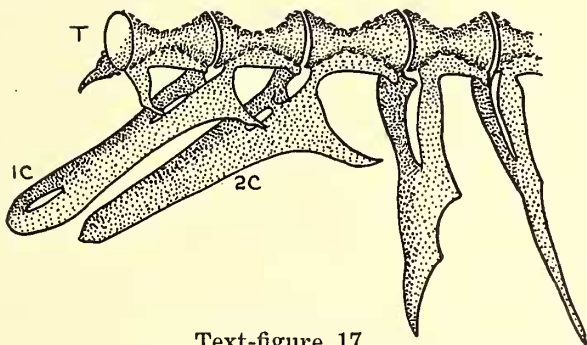
*Hypurals*: There are two hypurals present in young and adult specimens of all lengths. The large hypural is fan-shaped and median in position and approximately nine times broader on the distal margin than the other ventral hypural. The larger hypural supports approximately ten caudal rays. In most specimens there is a median slit in the basal end of the larger hypural. The length varies in the different specimens and cannot be associated with sex or age. In one embryo a faint line is present extending from the anterior end of the slit through the base of the hypural, but there is no line through the distal end of the hypural to indicate two distinct bones. Because of negligible evidence the larger hypural is considered a single structure. In most of the large females lines of various lengths are present radiating from the base of the large hypural toward the distal margin. These are not seen

in the young. There is considerable ossification in the caudal region of the embryos of this viviparous species. The second and smaller hypural is ventral in position and the basal part of the two lateral sides overlap part of the larger hypural near the urostyle. There is a thin wing of bone in the adults extending almost the full length of the anterior side of the hypural. This varies in length and shape in all specimens.



Text-figure 16.

*Lebistes reticulatus*. 1 day old, length 6 mm. Delicate ossification is present in the caudal area and considerably less in the head region. The distal tips of the spines and hypurals are unossified and the column is unsegmented.  $\times 66.3$ .



Text-figure 17.

*Lebistes reticulatus*. Anterior caudal haemals of adult male, length 18 mm. Shows the last trunk process and the two anterior caudal haemal processes specialized in the male. The first caudal spine has an opening for the insertion of the dorsal ends of the posterior interhaemals. The ribs and the neurals have been omitted for clarity.  $\times 25$ .

*Epural*: There is a single epural in all specimens. This bone resembles its counterpart, the smaller hypural, in shape and size.

*Caudal Fin Ray Count:*

$$\frac{3 + 9}{4 + 9}, \frac{2 + 10}{3 + 10}, \frac{3 + 10}{3 + 10} = \frac{12}{13}, \frac{13}{13}$$

*Additional Characters Worthy of Note:* As in *Gambusia*, the anterior caudal haemals are specialized in the male. The total number of caudal vertebrae is identical in the males and females of this collection of *Lebistes reticulatus*. But in the adult males, the anterior two caudal haemals are specialized. Each one is a long heavy bone and slants in a ventral and anterior direction as far as the dorsal ends of the interhaemals. Paired, pointed projections extend posteriorly from the lateral sides of the closed haemal arch and are capable of overlapping the next posterior haemal process. No male caudal haemal specialization can be found in the embryos and young specimens, and the anal fin shows no specialization in any of these young fish up to 12 mm. But in the smallest of the adult males, 13 mm., both caudal haemals and anal fins are completely developed.

No gross structural differences can be found in the six young, two and a half months old, which were the second generation reared in sea water.<sup>6</sup>

#### SUMMARY.

The following facts correlate the salient similarities found in the study of Bermuda Cyprinodontes.

Caudal fin count: *Fundulus* has more raylets than the *poecilids*: *Mollienisia*, *Gambusia*, *Lebistes*. The total count is increased in *Fundulus* by the greater number of raylets. The total count, less raylets, is nearly the same in the four species.

Caudal raylets extend anteriorly to approximately the fifth posterior neural and haemal in *Fundulus* but in the three species of *poecilids* the caudal raylets only extend to about the third posterior neural and haemal spines. In *Mollienisia* subspecies there is an increase in the raylets and along with this an additional neural and haemal is prolonged into the caudal contour.

*Fundulus* is oviparous and there is no modification of the ventral haemals in the male. The anal fin in the male and female is similar in *Fundulus*.

The *poecilids* are viviparous and there is modification of the ventral caudal haemals in the male, 2 in *Mollienisia* and *Lebistes*, with an opening in the tip of the first spine for the insertion of the posterior interhaemals, and 3 in *Gambusia* with no opening in the tip of the first spine.

In *Fundulus* the 5 posterior neural and haemal spines are elongated to the margin of the caudal contour. In *Mollienisia sphenops* 3 posterior spines are elongated and in *Mollienisia sphenops* subspecies, in most specimens examined, 4 posterior spines. In *Gambusia* and *Lebistes* 4 posterior spines are elongated.

Vertebral count: The total number of trunk vertebrae in the four species is almost the same. *Fundulus* 12-14, *Mollienisia* 12, *Gambusia* 13, *Lebistes* 12. The total number of caudal vertebrae is more variable, *Fundulus* having 19-21, *Mollienisia* 16-18, *Gambusia* 18-20, *Lebistes* 14-17.

All four species have 1 epural.

*Fundulus*, *Gambusia* and *Lebistes* have 2 hypurals—1 large fan-shaped hypural and 1 slender hypural. *Mollienisia sphenops* has 3 hypurals, 2 large and 1 slender bone. No separate elements can be found in the urostyle of any specimens of the four species studied.

<sup>6</sup> Hollister, 1934. Salt and Fresh Water Viability of Fish.